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Patent Office  
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I, JONNE YABSLEY, TEAM LEADER EXAMINATION SUPPORT AND SALES hereby certify that annexed is a true copy of the Provisional specification in connection with Application No. PQ 2907 for a patent by HOTFLO PTY LTD filed on 16 September 1999.

I further certify that the name of the applicant has been amended to HOTFLO DIECASTING PTY LTD pursuant to the provisions of Section 104 of the Patents Act 1990.

WITNESS my hand this  
Sixth day of February 2002

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5

AUSTRALIA

Patents Act 1990

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**PROVISIONAL PATENT SPECIFICATION**

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**INVENTION TITLE:** Hot Sprue System for Die-casting

The invention is described in the following statement:—



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**TITLE:** Hot Sprue System for Die-casting

### TECHNICAL FIELD

This invention relates to high-pressure die-casting methods and apparatus, and  
5 more particularly, to hot sprue systems for use with hot-chamber, high-pressure  
die-casting.

### BACKGROUND TO THE INVENTION

There is a very large installed base of hot-chamber, high-pressure, die-casting  
10 machines dedicated to the production of small die-cast products of zinc, lead, tin  
magnesium, aluminium and their alloys. A typical machine 10 of this type is shown  
in Figure 1. A pool of molten metal 12 is held in a heated pot 14 from which 'shots'  
of melt are forced, by a plunger 16 working in a submerged cylinder 18, through a  
gooseneck 20 and an externally heated connecting nozzle 22, into a cavity 24  
15 formed between a fixed die 26 and a moving die 28. Fixed die 26 is mounted on a  
fixed platten 30 and moving die 28 is mounted on a moving platten 32 that is  
pressed toward the fixed platten by the piston 34 of a hydraulic or pneumatic ram,  
the clamping force being taken by tie-rods 36. When dies 26 and 28 are closed,  
plunger 16 is driven downwards into cylinder 18 by the piston 38 of a pneumatic  
20 ram 40 to force a shot of melt into cavity 24 and to hold the pressure until it has  
frozen. After which, plunger 16 is raised to suck the remaining liquid melt from  
nozzle 22 and gooseneck 20 back into melt pool 12. To assist the flow-back of  
melt at the end of a shot, nozzle 22 normally slopes upward to fixed die 26.  
Indeed, for the same purpose, the whole press portion of the machine (comprising  
25 the dies and plattens) can be tilted slightly downward towards nozzle 22.

At the commencement of a shot, the melt is conveyed by heated nozzle 22, via a  
sprue bush 42 fitted in the back of fixed die 26, to a sprue channel 44 that delivers  
the melt to the interface or parting line 46 of dies 26 and 28. It is then conveyed  
30 along the interface 46 by one or more runner channels 48 into cavity 24. As the  
injection pressure in such machines is commonly between 10 and 30 mPa, nozzle  
22 must be clamped strongly between sprue bush 42 and gooseneck 20 to avoid  
leakage. The use of sprue bush 42 assists in forming the seal at the die end of

nozzle 22 and it has the advantage that it can be easily replaced should a freeze-plug form therein after a shot.

Sprue channel 44 is strongly tapered so that it widens toward die face 46 from sprue bush 42 and is of such a volume that the freeze-point will occur in sprue channel 44 inwards of bush 42 at the end of a shot. This common arrangement of sprue and runner channels allows the cast sprue and runner(s) to be easily ejected from the dies together with the attached products, after the dies have opened. However, the sharp right angle corner between the inner end of sprue channel 44 and the start of runner channel 48 causes undesirable turbulence in the flow of the melt. Each runner channel 48 is normally connected to its respective cavity 24 via a narrow slot-like opening called a gate (not shown in Figure 1). This forms a thin and easily broken connection between the cast product and its associated runner casting

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It will be appreciated from the above that, in this specification, the sprue and runner channels are the channels that convey the melt within the dies to the cavity or cavities. The sprue channel conveys the melt from the back to the front of the fixed-die, while the runner or runners convey it from the inner end of the sprue channel to the cavity or cavities along the interface between the fixed and moving dies. The sprue and runner castings are the die-cast metal which solidifies in the sprue and runner channels (respectively) at the end of a shot, and are commonly referred to simply as the sprue and runner(s).

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Though hot-chamber die-casting is very common, relatively trouble-free and can produce high quality product at high production rates, a major disadvantage of the method is the large amount of metal contained in the sprue and runner(s) compared with the metal in the product. After separation, the sprues and runners are generally remelted and reused, but this represents high energy losses and causes melt contamination.

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It will be appreciated that hot-chamber die-casting is a similar process to the injection moulding of plastics materials. While both can pump shots of melt into cavities via sprue and runner systems, the problem of remelt is much less with

injection moulding. In injection moulding, it is common to employ electrically heated sprue-channels (often called 'nozzles' in the injection moulding context), or electrically heated cores (called 'hot-tips') within the sprue-channels, to eliminate the generation of sprues. Indeed, if such a device is used to inject molten plastic directly into a cavity, both runners and sprues can be eliminated. It is even possible to use a mechanical valve in the sprue nozzle or hot-tip to close the channel at the entrance to the cavity so that the molten plastic feed-line can be kept pressurised between shots, allowing higher production rates.

- While it has been suggested from time to time (see for example US patents 4,304,544 and 4,795,126 to Crandell) that heated nozzles and hot-tips designed for injection moulding can simply be applied for direct-injection in hot-chamber die-casting, this has not been the case. The much higher melting point, thermal conductivity and electrical conductivity of metals relative to plastics have made direct-injection die-casting a most difficult endeavour.

The most notable attempt at direct-injection in hot-chamber die casting known to the applicant is that undertaken by the Battelle Columbus Laboratories for the International Lead Zinc Research Organisation [ILZRO] during most of the 1980s. A large number of progress reports were prepared and published on this work by ILZRO or Battelle. An early such report was published in a paper (No. G-T83-066) entitled "Heated Manifold, Direct-Injection System for Zinc Die Casting" by Groeneveld and Kaiser of Battelle and Herrschaft of ILZRO at the International Die-casting Congress and Exposition, Minneapolis, October 31 to November 3, 1983. A further progress report, entitled "Commercial Application of the Heated-Manifold Direct-Injection System of Zinc Die Casting" was published in a paper at the Exposition of June 3-6 1985 in Milwaukee, WI, with Groeneveld of Battelle as primary author. A further progress report (No. 30) on the ILZRO direct-injection project (authored by Groeneveld) was published in March 1988, noting that "several million castings have been made by direct injection". Production rates and product quality were reported to be at least equal to conventional die-casting using runners and sprues.

Despite the obvious and great benefits offered by direct-injection die-casting, the teachings of the above publications (particularly, the Battelle work) do not appear to have been applied in practice by die-casters. The principal reason for this appears to be that die and 'nozzle' design methods for direct injection have not been developed to anywhere near the same reliability or sophistication as die, runner and sprue design techniques for conventional hot-chamber die-casting. Consequently, a great deal of highly-expert and highly-expensive experimentation must be undertaken before any given product, cavity, die and 'nozzle' combination can be made to work satisfactorily. Furthermore, direct-injection in multi-cavity dies involves major changes to existing die-casting machines with respect to metal flow and control, making tool-changing a lengthy process. In short, implementation of direct-injection die-casting appears to be beyond the technical ability as well as the financial capacity of the great majority of hot-chamber die-casters.

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#### **OUTLINE OF INVENTION**

The present invention is based upon the realisation that a significant part of the benefit offered by direct-injection die-casting can be achieved with very little change to current die design and no change to hot-chamber machine layout, if heated sprue channels are employed with substantially conventional runner channels. This will allow molten metal in the sprue channel to run back into the chamber at the end of a shot and the freeze point to occur in the runner channel(s) near the end of the sprue channel, or at the tip of the sprue itself. This permits the resulting runner casting(s) to be ejected with the attached product(s) in the normal manner.

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Such a 'sprueless' die-casting technique avoids the production, recovery and remelting of sprues (achieving most of the savings of direct-injection) with minimal change to die design, no change to machine layout and without any need for troublesome valved 'nozzles' at the gate. Furthermore, the use of a hot-sprue die-insert allows the junction between the sprue and runner channels to be optimised for streamlined melt-flow free of the previously dominant need to taper the sprue channel sufficiently to permit extraction of the sprue casting.

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It is preferable (as is conventional) for the sprue channel to extend roughly horizontally in the fixed die so as to be orthogonal to the front and back die faces, and for interface of the sprue channel and the principal runner channel to be a smooth curve that subtends an angle of about  $90^\circ$ . It is also preferable that this curved end of the sprue channel decrease in section in a smooth and uniform manner so that the melt accelerates as it flows around the curve to enter the runner channel. To facilitate flow-back of melt in the hot sprue channel at the end of a shot without excessively heating the die, it is desirable for freeze-off to occur in the curved portion of the sprue channel at the sprue tip. To facilitate the formation of the curved part of the sprue channel and to allow ready ejection of the short curved portion of the sprue with its connected runner at the end of a shot, it is desirable for the convex half of the curved portion of the sprue channel to be formed by the tip (or inner end) of a tubular hot sprue-body insert in the fixed die and for the concave half to be formed by the inner end of a sprue-tip insert in the moving die.

It is preferable that the sprue-tip insert in the moving die have its own cooling means (such as provision for water circulation) so that its temperature can be adjusted independently of the rest of the moving die so as to ensure that freeze-off occurs in the curved part of the sprue channel. For this purpose, it is desirable for the tip-insert to include temperature sensor means so that automatic regulation can be effected. Similarly, it is desirable for the sprue-body insert to include temperature sensor means so that it can be kept at a sufficiently high temperature to ensure flow-back of the melt in the main part of the sprue channel after a shot.

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It will be appreciated that mating die inserts like those required for the sprue-body and the sprue-tip are familiar to average die-casting toolmakers and that the setting of the appropriate temperatures for the sprue-body and sprue-tip to achieve appropriate freeze-off are well within the competency of average machine operators. Moreover, the remainder of the tool design is essentially unaffected by the use of the hot-sprue system indicate. Normal cavity inserts and ejection mechanisms can be used. Where there is more than one cavity in a die-set branching or radiating runner channels can be cut to connect the end of the curved sprue channel with each cavity in the normal manner.

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It will also be appreciated that, instead of the simplest arrangement in which only one curved sprue channel feeds only one principal runner channel, multiple curved sprue channels can be formed between the inner ends of the sprue body-  
5 insert and the sprue-tip insert. Thus, one or two pairs of opposed curved sprue channels can be used to feed two or four separate runner systems, or three curved sprue channel portions can be formed between the inner ends of the body-insert and the tip-insert to feed three runner systems.

10 From other aspects, the present invention is alternatively or further indicated, without necessary restriction, by the indicative claims that follow the description of examples below.

#### **DESCRIPTION OF EXAMPLES**

15 Having portrayed the nature of the present invention, two examples will now be described with reference to the accompanying drawings. However, those skilled in the art will appreciate that many variations and modifications can be made to the chosen examples without departing from the scope of the invention as outlined above.

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In the accompanying drawings:

Figure 1 is a part-sectional elevation of a typical prior art hot-chamber die-casting machine.

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Figure 2 is a diagrammatic sectional elevation of portion of a die-casting machine including a die set fitted with sprue inserts formed in accordance with the chosen example of the present invention.

- 5 Figure 3 is an enlarged detailed sectional elevation of portion of the sprue inserts of Figure 2.

Figure 4 is a similar view to that of Figure 3 showing a modified form of the sprue inserts of Figure 3.

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Figure 5 is a perspective view of the sprue-body insert of Figures 3 and 4.

Figure 6 is a perspective view of the sprue-tip insert of Figures 3 and 4.

- 15 Figure 7 is a sectional elevation of a die-set having a sprue and a sprue-tip insert formed so as to feed two opposed runner channels.

Figure 2 shows the portion of a conventional die-casting machine 100 in which the die-set 102 is mounted between a fixed platten 104 and a moving platten 106.

- 20 The die-set comprises a fixed tool backplate 108 secured to fixed platten 104 and a moving backplate 110 fixed to moving platten 106. The fixed die or cavity plate 112 is secured to fixed backplate 108 while the moving die or cavity plate 114 is normally attached to moving backplate 110. The parting plane between the dies 112 and 114 (ie, the die faces) is shown at 115. A bolster 116 is usually secured to moving backplate 110 and serves to spread the force of moving platten 106 over the whole area of the moving die 114. An ejector assembly 118 also forms part of the die-set and, for simplicity, only one ejector pin 120 is shown. Finally, the mould cavity or cavities (not shown) are formed in a pair of mating cavity inserts, comprising moving insert 122 and fixed insert 124.

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The hot sprue system of the first example comprises a tubular cylindrical sprue body insert 130 mounted in fixed cavity plate 112 and a mating cylindrical sprue tip insert 132 mounted in moving cavity plate 114 that define a sprue channel 134. Sprue body insert 130 extends right through die plate 112 so that it is disposed

perpendicular to parting line 115. Sprue channel 134 comprises a straight portion 134a that is formed by a parallel-sided bore in sprue body 130 and a bent portion 134b that is formed between sprue tip insert 132 and sprue body insert 130, bent portion 134b taking the sprue channel through a smooth 90° curve to meet a  
5 runner channel 136 formed in the mating faces of die plates 112 and 114. The tubular sprue body insert 130 is externally wound with an electrical heating element 138 that is fitted with one or more thermocouple temperature sensors (not shown), the heating element and sensor leads being generally indicated at 140. Sprue body insert 130 is located in fixed die 112 in the normal place where a  
10 conventional sprue channel would be formed so that it is in line with the heated nozzle 142 of the standard die-casting machine 100. It is held in place by a location ring 144 that is, in turn, secured by bolts 146 to fixed backplate 108.

Although the portion of sprue channel 134 that is formed by the bore 134a of  
15 sprue body 130 is shown having substantially parallel sides in this example, it is envisaged that it can be tapered in the opposite manner to normal; that is, so that the widest end of the bore is outermost. It is also preferable for the curved portion 134b of channel 134 to continue this smooth taper so as to join with runner a 136 that has a substantially smaller cross-section than the inlet to body insert 130.  
20 This has two advantages: the melt is accelerated in a uniform manner from entry to the sprue to the runner gate, and the reverse-tapered bore facilitates run-back of melt contained within sprue channel 134 at the end of a shot.

Referring more particularly to the enlarged details of Figures 3 and 4, the outer  
25 end or head 148 of sprue body insert 130 is dished at 150 to form a seat for nozzle 142, head 148 thereby performing the function of a sprue bush in providing a sealing face for the nozzle. Head 148 includes an integral cylindrical flange 152 that extends forwards to provide an annular seat 154 by which sprue body insert 130 can be accurately located against the outer face of fixed die plate 112.

30 In the example of Figure 3 the axial position of body-insert 130 can be adjusted by the use of a spacing washer or a series of shims 156, the inner end of insert 130 being free to move towards or away from the inner end of sprue tip insert 132. Thus, by the use of spacer 156, proper mating of the ends of the tip and body

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inserts can be achieved. An alternative way of locating body-insert 130 is shown in Figure 4 wherein the inner end of insert 130 is formed with an external shoulder 158 that bears the clamping pressure of ring 144, any fine adjustment required to ensure proper mating of the inner ends of body insert 130 and tip-insert 132 being  
 5 made by the use of shims 160 between the outer end of tip-insert and the bottom of its socket in moving die plate 114. In general, the arrangement of Figure 4 is preferred because the clamping pressure of bolts 146 and ring 144 provides a positive seal at shoulder 158 against the ingress of casting metal into the chamber 162 in fixed die-plate 112 that accommodates body-insert 130. Finally, it is to be  
 10 noted that a slot 164 is formed in flange 152 at the head 148 of body-insert 130 to accommodate leads 140.

Referring again to Figures 3 and 4, sprue-tip insert 132 is secured in its socket within moving die-plate 114 by a pair of bolts 166 arranged on either side of the  
 15 centre-line of the insert. This allows a thermocouple temperature sensor 168 to be arranged centrally within the insert and its leads (not shown) to pass through a suitable bore (not shown) in the outside of plate 114. A cooling passage 170 is formed in insert 132 and fitted with a baffle insert 172 of conventional design. Two insulated water pipes 174 and 176 are led laterally through plate 114 to connect  
 20 with passage 170 and baffle 172. Thus, a cooling liquid can be circulated through passage 170 to effect the cooling of insert 132 relative to body insert 130 and moving die-plate 114.

Referring now to Figures 5 and 6, which are enlarged perspective views of sprue  
 25 body-insert 120 and tip-insert 132 of Figure 3, it should be noted that body-insert 130 of Figure 5 has been rotated 180° about its longitudinal axis with respect to Figure 3 in order to better illustrate the shape of its inner end generally indicated at 176. Inner end of tip-insert 132 is generally indicated at 178.

30 Inner ends 176 and 178 of body-insert 130 and tip insert 132 are provided with half-round radial faces 180 and 182 (respectively) that abut one another when both inserts are in place. Extending from end 176 of body-insert 130 is a convex-curved protrusion 184 that mates with a corresponding concave-curved recess 185 on inner end 178 of tip-insert 132. A curved groove 186 is formed in the

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centre of protrusion 184 and joins with bore 134a of body insert 130, groove 186 forming the inner half of curved sprue channel 134b. A matching curved groove 188 is formed in concave recess 185 on tip-insert 132, groove 188 forming the outer half of curved sprue channel 134b. [See also Figures 3 and 4.]

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Prior to use, inserts 130 and 132 are aligned and fixed in place in their respective recesses in die plates 112 and 114, after axial adjustment of one or the other insert to ensure that the mating end portions will mate in a snug manner that will be free of any leakage of melt under pressure. Moving platten 106 is then moved  
 10 toward fixed platten 104 to forcibly close dies 112 and 114. A shot of melt is then injected into the cavity or cavities in cavity inserts 122 and 124 via the straight bore 134a of body-insert 139, the curved portion of sprue channel 134b and the runner system 136. Pressure is held on the melt for a set time determined during a set-up procedure such that, with the preset temperatures of body-insert 130 and  
 15 tip-insert 132, freeze-off occurs in the curved portion 134b of sprue channel 134 while the melt remains liquid in the bore 134a of channel 134. When pressure on the melt is relieved, the liquid portion in body-insert 130 flows back into the hot chamber via nozzle 142. The dies are then opened by withdrawing platten 106 so that the ejector pins (only pin 120 being shown) operate to eject the product and  
 20 runner from their respective cavities, it being noted that pin 120 acts on the stubby curved sprue formed in channel portion 134a.

In the system 200 of Figure 7, the sprue-body insert 201 is mounted centrally in the fixed die-plate 202 and has a sprue channel 203 that feeds two diametrically  
 25 opposed runner channels 204 and 206 that in turn feed two pairs of cavity inserts 208 and 210 arranged about parting line 212 on either side (above and below) sprue-body 200. The sprue-tip insert 214 is, as before, mounted in the moving die plate 216 opposite and in-line with sprue-body 201. In this example, sprue-body 201 has a head flange 218 by which it is located in a recess in fixed die-plate 202 and by which it is directly bolted, with bolts 220, to die-plate 202. Similarly, sprue-  
 30 tip 214 is formed with an integral flange 222 by which it is located in a recess in moving die-plate 216 and by which it is directly bolted to moving die-plate 216 with bolts 224.

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Instead of one curved sprue-tip channel formed between body insert 200 and tip insert 214, the inner end of each insert is shaped to form a pair of opposed curved sprue-tip channels 226 and 228 that feed opposed runner channels 204 and 206. Each sprue-tip channel is shaped in a similar manner to the single curved channel  
5 of the previous examples and functions in the same manner.

In this example, it will be seen that the sprue channel 203 formed by the bore of body insert 200 is tapered so that its outer end is wider than its inner end. This has the advantage of assisting the melt in the channel run back into the nozzle  
10 (not shown) under gravity at the end of a shot. The taper is opposite to that of a normal sprue channel employed in the art and could not be used in a sprue channel that was not heated, as the resultant sprue could not then be extracted as the dies opened. The tapered sprue channel also has the advantage that the melt flow is accelerated in a consistent and uniform manner from the time it enters the  
15 sprue channel until it reaches the gates (not shown) of the cavities (not shown).

As in the previous examples, sprue-tip insert has a central cooling finger 230 and a temperature sensing element (not shown). However, since there are two runner channels, two ejector pins 232 and 234 are provided, one to eject each runner in  
20 each runner channel.

It will be appreciated from the above description that this sprue-less die-casting method can be easily introduced and operated with standard hot-chamber die-casting machines using only the normal skills of a tool-maker or machine-setter/operator. Only the simplest of adjustment and set-up procedures are  
25 required from a machine-setter. Yet, the economies and benefits of sprue-less die-casting are substantial. However, as previously indicated, many variations and changes can be effected without departing from the scope of the present invention.

**INDICATIVE CLAIMS**

- 1 A hot-chamber high-pressure die-casting method employing a fixed die, a movable die, a mould cavity formed between the fixed and movable dies, a sprue  
5 channel formed in the fixed die for conveying molten die-casting metal from the hot chamber into the die and a runner channel for conveying molten metal from the sprue channel into the mould cavity via a gate formed between the fixed and movable dies, the method comprising the steps of:
- 10 • heating the sprue channel to a temperature that is higher than that of the fixed die and approximating the melting point of the die-casting metal,
  - controlling the temperature of the runner channel so that it is below the melting point of the die-casting metal,
  - 15 • injecting a shot of molten metal into the sprue channel, runner channel and mould cavity,
  - allowing molten die-casting metal remaining in the sprue channel to empty therefrom while allowing die-casting metal in the runner channel to solidify to form a runner and while allowing die-casting metal in the mould cavity to solidify to form a product,
  - 20 • separating the movable die from the fixed die, and
  - ejecting the product from the mould cavity together with the runner from the runner channel.
- 2 A hot-chamber, high-pressure die-casting method comprising the steps of:
- 25 • injecting a shot of molten die-casting metal into a mould cavity via a sprue channel that is formed in a fixed die and then via a runner channel that is formed at least in part between said fixed die and a movable die which cooperates with the fixed die to form the mould cavity,
  - 30 • heating said sprue channel above the melting temperature of the die-casting metal,
  - allowing any molten die-casting metal remaining in the sprue channel after the shot to empty therefrom,

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- allowing die-casting metal in the runner channel and in the mould cavity to solidify,
- separating the movable die from the fixed die, and
- ejecting the solidified metal from the mould cavity and from the runner channel.

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3 A method according to claim 1 or 2 including the step of:

- Conveying the shot of molten die-casting metal through an angle of at least  $45^{\circ}$  and preferably  $90^{\circ}$  while it is within the runner channel.

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4 A die-set for use in a hot-chamber, high-pressure die-casting process, comprising:

- a fixed die forming part of a mould cavity,
- a movable die also forming part of said mould cavity,
- a gate through which molten die-casting metal can be introduced into the cavity, said gate being formed between adjacent portions of said fixed and movable dies when said fixed and movable dies are brought together,
- a sprue channel formed in the fixed die adapted to accept molten metal under pressure from the hot-chamber,
- heater means associated with said sprue channel adapted to ensure that die-casting metal within the sprue channel remains molten,
- a runner channel adapted to convey molten die-casting metal from said sprue channel to said gate, and via the gate into said cavity after the fixed and movable dies have been brought together, and
- temperature control means associated with the runner channel adapted to ensure that die-casting metal within the runner channel solidifies together with die-casting metal within the cavity, and
- ejector means adapted to eject a solidified runner from the runner channel together with a solidified casting from the mould cavity, after separation of the movable and fixed dies.

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5 A die set according to claim 4 wherein:

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- the runner channel is formed in part by the fixed die and in part by the movable die, and
- the runner channel is formed so as to convey molten die-casting metal through an angle of at least  $45^{\circ}$  between the sprue channel and said gate.

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6 A sprue insert for fitting within the fixed die of a high-pressure, hot-chamber die-casting apparatus, the fixed die having a parting face that at least in part defines a gate through which molten die-casting metal can be injected into a mould cavity, wherein said sprue insert:

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- is tubular, forming a sprue channel having an open outer end and an open inner end,
- is adapted for fitting within the fixed die so that said outer end is located at an external surface of the fixed die and so that said inner end is located in the vicinity of the mating face of the gate,
- said sprue insert includes heater means and temperature sensing means for use in holding the temperature of the sprue channel at least at the melting temperature of the die-casting metal, so when the sprue insert is in use, metal contained within the sprue channel after each moulding shot can drain back to the hot chamber.

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7 A sprue insert according to claim 6 wherein:

- the sprue channel has a longitudinal axis and is tapered so that said open outer end is larger than said open inner end, whereby molten metal held within the sprue channel after a moulding shot will run under gravity toward and from the open outer end when the sprue insert is located with said longitudinal axis substantially horizontal.

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8 A sprue insert according to claim 6 or 7 and for use in die-casting apparatus having a movable die that cooperates with the fixed die to define the gate, wherein:

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- the sprue insert includes an inner portion that extends inwardly beyond said inner end to the gate, said inner portion is adapted to cooperate



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with the movable die, when the fixed and movable dies are brought together, to define a runner channel that extends between said inner end and the gate, such that any solidified runner formed within said runner channel after a casting shot can be removed with a casting formed in the moulding cavity upon separation of the movable die from the fixed die.

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9 An insert set for use with a die set for use in high-pressure, hot-chamber die-casting process, the die set including a fixed die and a movable die having mating faces that can be brought together to define (i) at least portion of a mould cavity and (ii) a gate through which molten die-casting metal can be injected into the cavity, wherein:

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- said insert set includes a tubular sprue insert defining a sprue channel, said sprue insert having an outer end and an inner end and being adapted for fitting within the fixed die so that said outer end is located at an external surface of the fixed die and so that said inner end is located in the vicinity of the mating face of the fixed die,
- said sprue insert includes heater means capable of holding the temperature of the sprue channel at least at the melting temperature of the die-casting metal,
- the insert set also includes a runner insert for fitting within the movable die, said runner insert having an outer end and an inner end and being adapted for fitting within the movable die so that the outer end of the runner insert is located at an external surface of the movable die and the inner end of the runner insert is juxtaposed with the inner end of the sprue insert when the mating faces of the fixed and movable dies are brought together, and
- said sprue insert and said runner insert cooperate to define a runner channel that extends from said sprue channel to said gate, when the fixed and movable dies are brought together.

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10 An insert set according to claim 9, wherein:

- said sprue insert includes temperature sensing means for use, in conjunction with said heater means, for controlling the temperature of the sprue channel.

5 11 An insert set according to claim 9 or 10 wherein:

- said runner insert includes temperature control means capable of holding the temperature of the runner channel below the melting temperature of the die-casting metal.

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HotFlo Diecasting Pty Ltd

By its Attorney

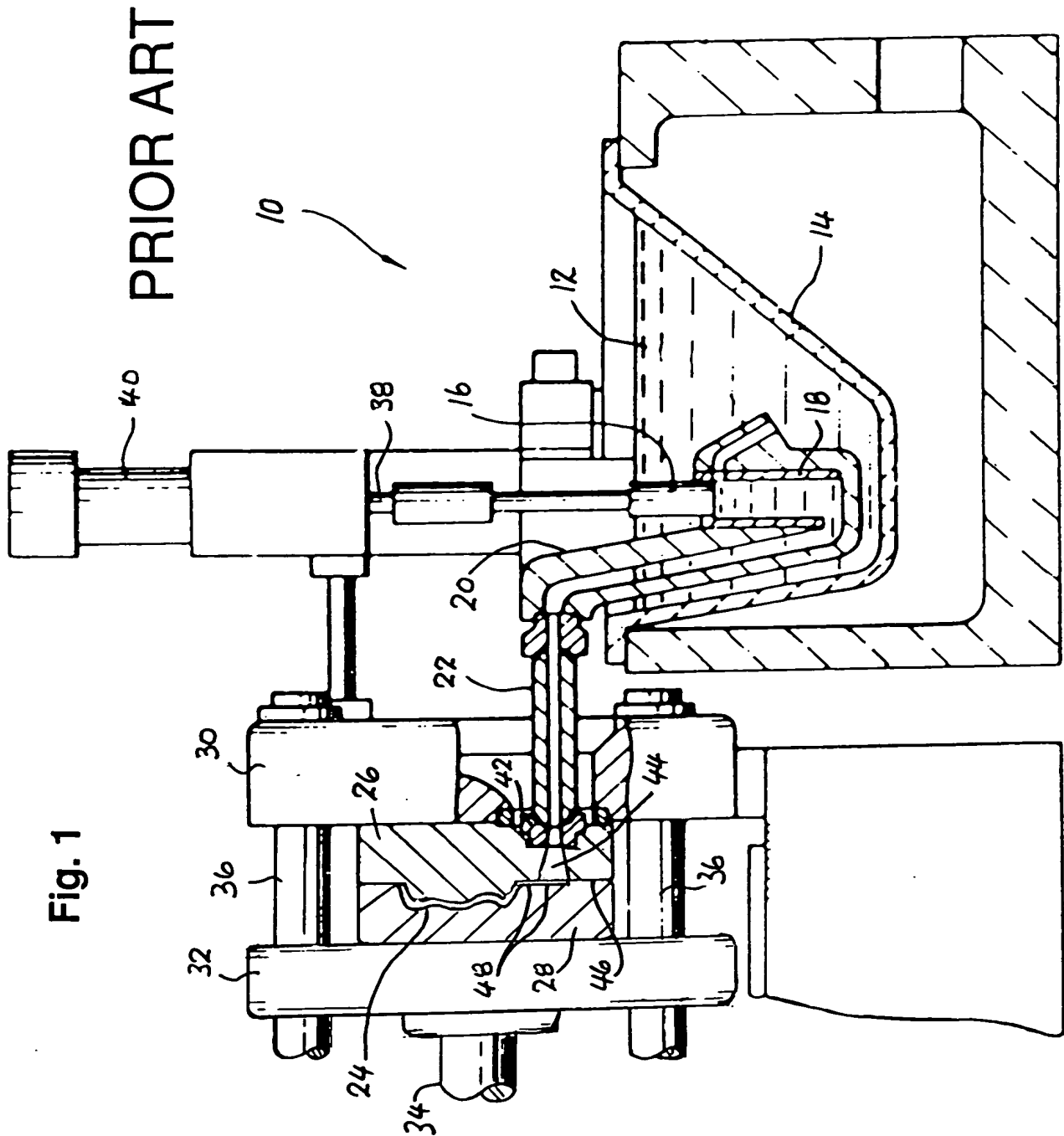
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11 September 1999



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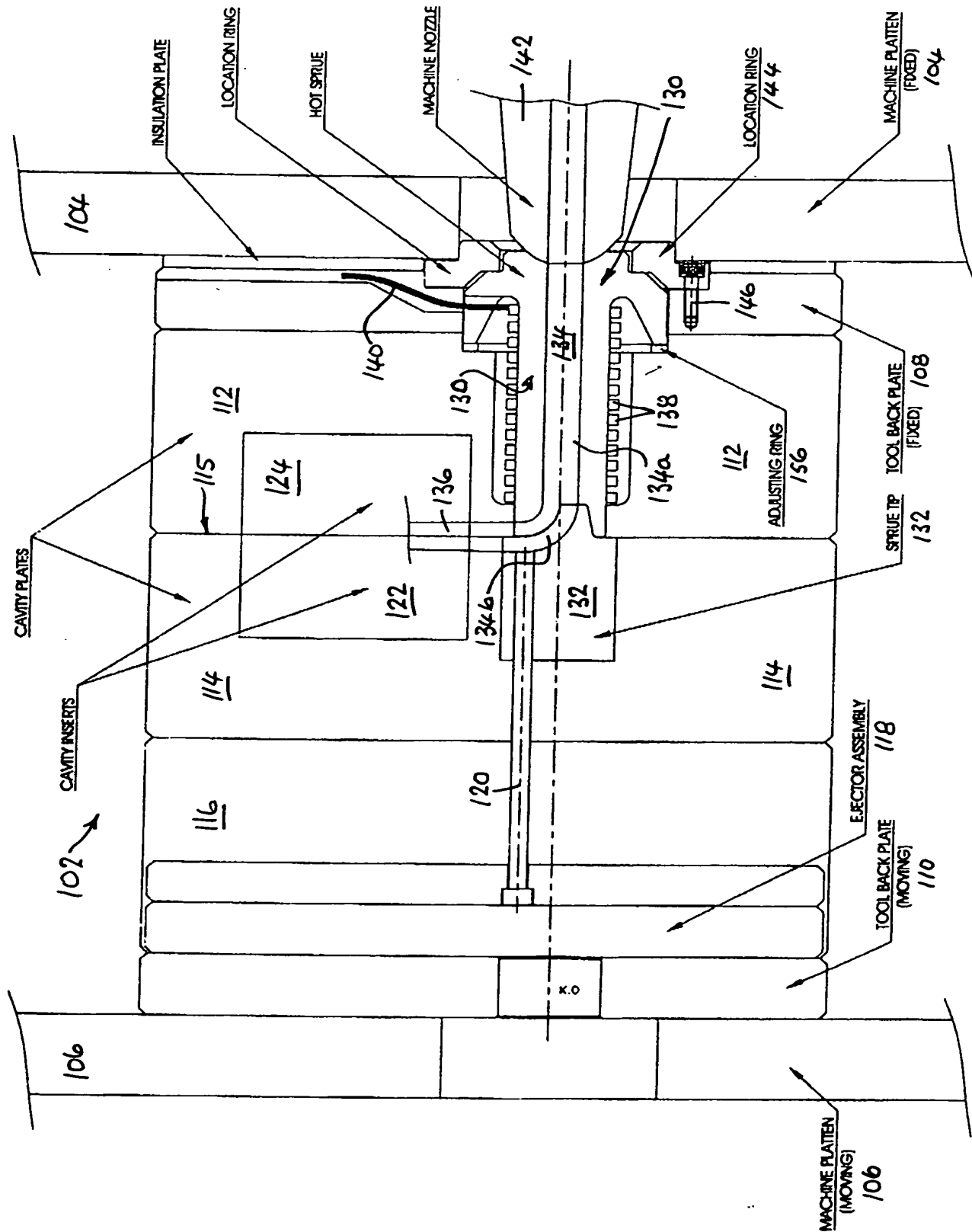
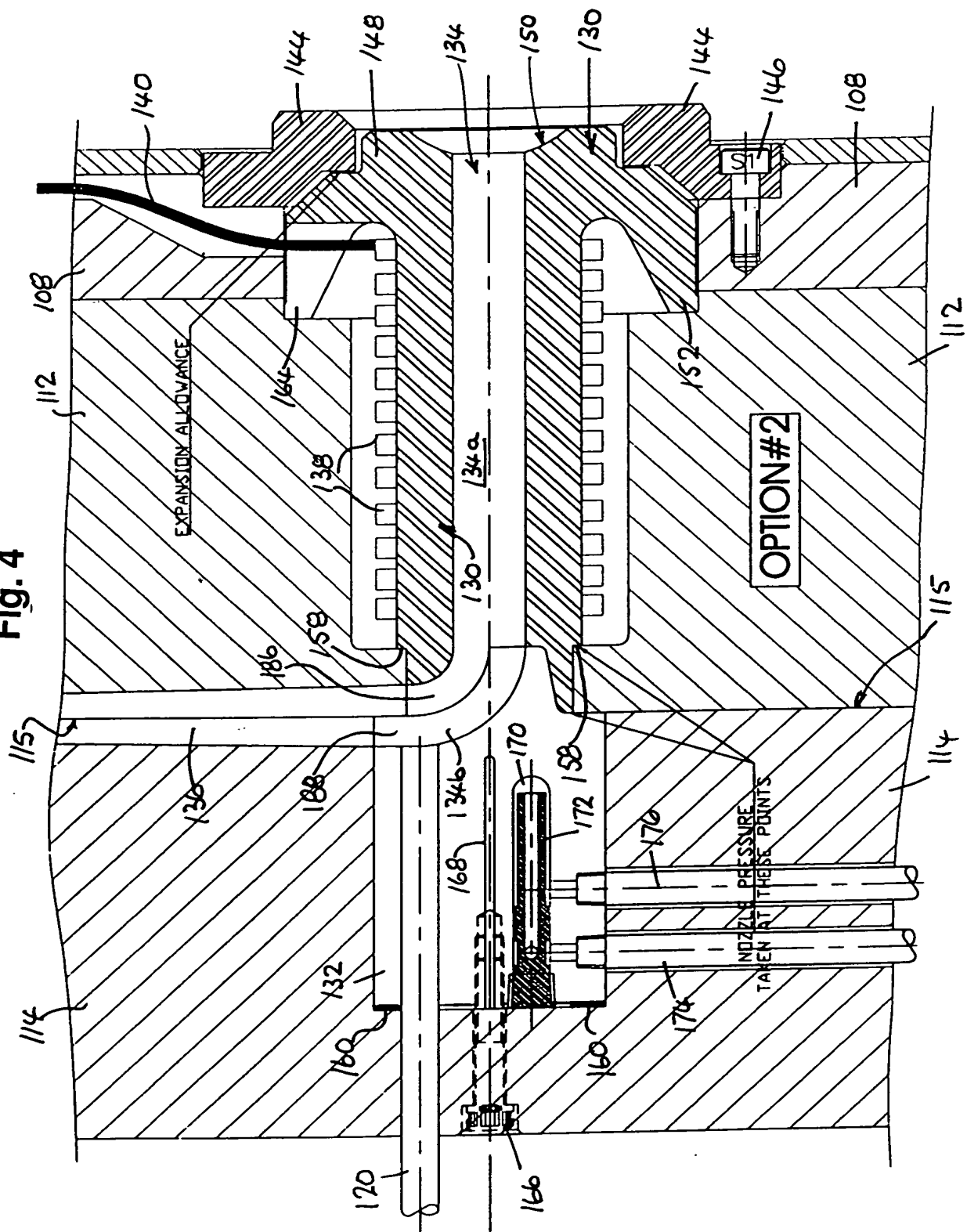


Fig. 2

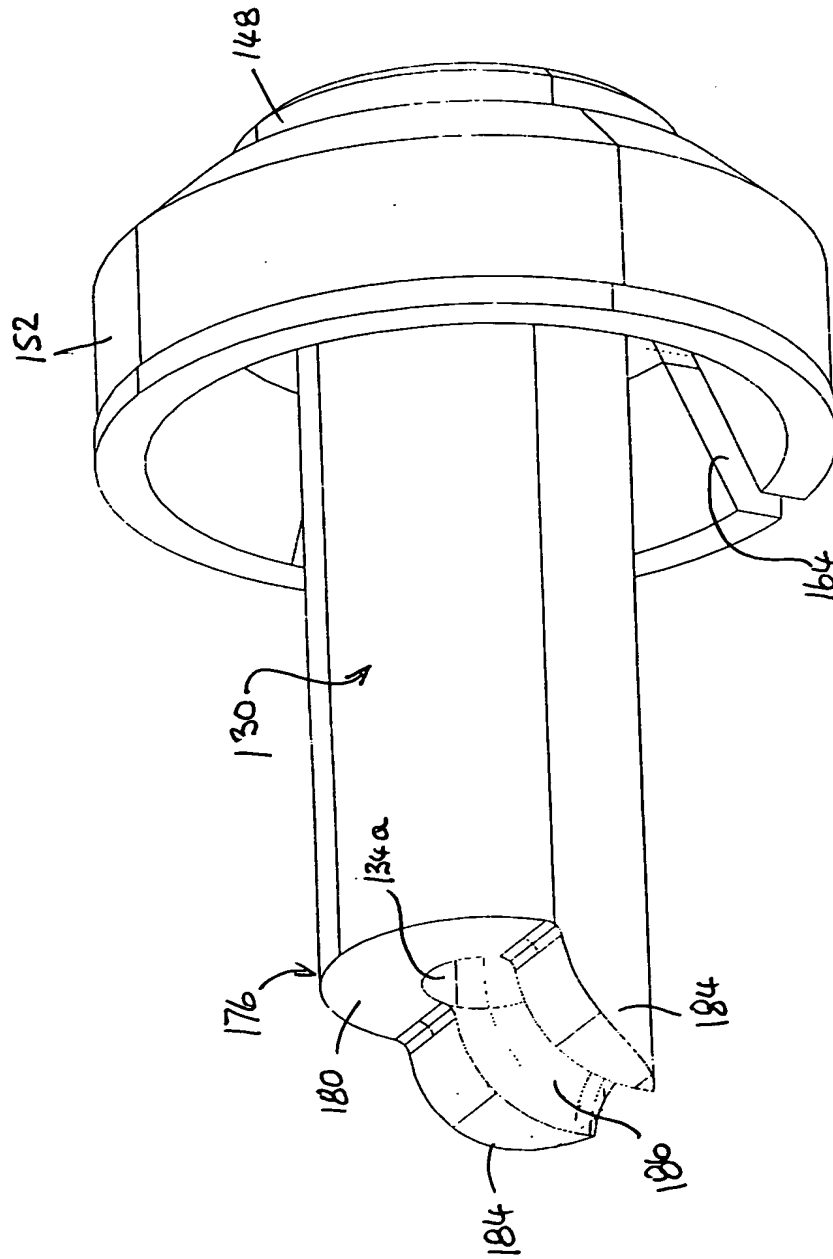


Fig. 4



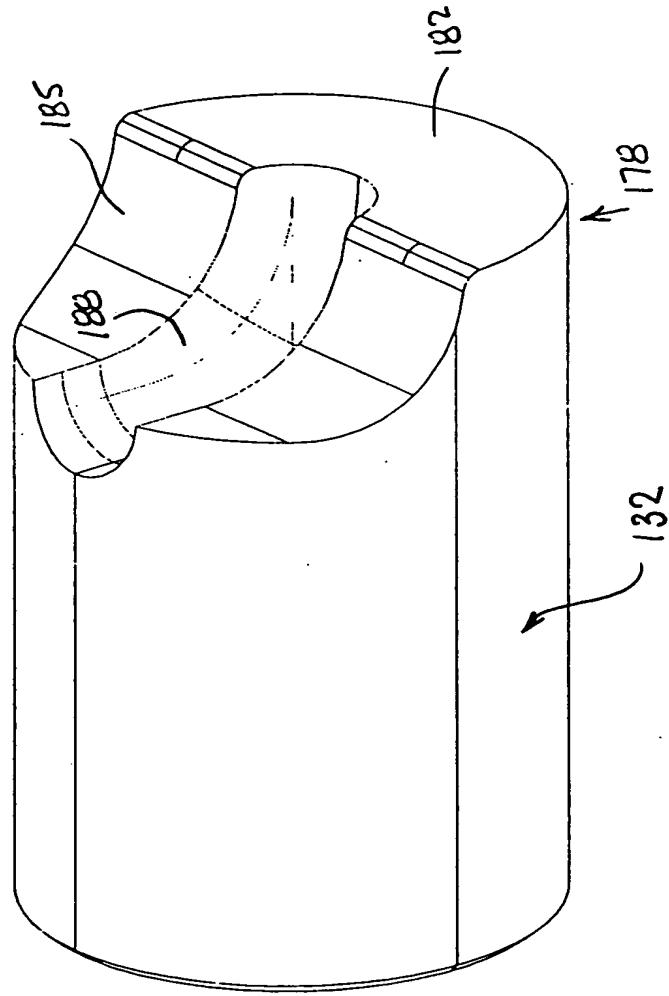
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Fig. 5



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Fig. 6





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Fig. 7

